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NEW SAND DOLLARS (ECHINOIDEA) OF THE GENERA  
*MERRIAMASTER* AND *DENDRASTER* FROM  
PURISIMA FORMATION, CALIFORNIA

By

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ABSTRACT: *Merriamaster weaveri* n.sp. and *Dendraster sullivanii* n.sp. are described from a sandstone within the early Pliocene Tahana Member of the Purisima Formation from a locality near San Gregorio Beach, California. Three species (*turneri*, *jalorensis*, *purisimaensis*) of *Patinopecten* (*Lituyapecten*) occur in sequence in a stratigraphic interval of 45 m at this locality with *turneri* associated with the echinoids and *purisimaensis* the highest. Fossils in the overlying Pomponio and San Gregorio members suggest a correlation of these members with the uppermost type Jacalitos Formation or basal Faunizone F of Adegoke's 1969 classification of the Coalinga-Reef Ridge, California sequence. The Tahana Member probably correlates with Adegoke's Faunizone E.

INTRODUCTION

Specimens of the sand dollar-type echinoids *Merriamaster* Lambert and *Dendraster* Agassiz are associated in the Tahana Member (Cummings, Touring and Brabb 1962: 197-200) of the Purisima Formation in exposures in the seacliff south of San Gregorio Beach, California (Fig. 1). This locality is a little over 16 kms south of the town of Half Moon Bay. Very probably this is the same general locality as that from which *Scutella perrini* Weaver (= *Merriamaster perrini* in current nomenclature) was reported in the Santa Cruz Folio (Branner, Newson and Arnold 1909:6). The same record was subsequently repeated by Kew (1920:130, as *Dendraster perrini*) and by Grant and Hertlein (1938:68, as *Mer-*

*riamaster perrini*). Weaver (1908:273), in his description of *S. perrini*, also noted that "Other specimens closely resembling this form have been found at San Gregorio . . ." J. P. Smith (1912:167) listed *Astrodapis perrini* Weaver as one of the ". . . characteristic upper Miocene species [that] range over into lower Pliocene, and become extinct in the Purisima-San Diego fauna." Presumably this is Weaver's *Scutella perrini*, inasmuch as the latter name is used in Smith's checklist on p. 170. Subsequently, Smith (1919:145) used the name *Dendraster perrini* Weaver in his faunal lists for the Purisima. Presumably all three names as used by Smith refer to the same taxon and were probably based on the records by Weaver and by Branner et al.

Martin (1916:243, and checklist, p. 251) lists *Scutella perrini* Weaver from "... the upper sandstone [sic] member of the Purisima Formation, chiefly from the sea-cliffs south of Half-moon Bay." Martin's collections in the Museum of Paleontology at Berkeley (none of the California Academy of Sciences collections from the Purisima Formation were made by Martin) contain no specimens of *Merriamaster*, so presumably the inclusion of *M. perrini* in his list is based on the records by Weaver and by Branner et al. We have found no other published record of a *Merriamaster* from the Purisima Formation of the type area, and although Cummings et al. (1962) recorded *Dendraster* from the San Gregorio Member, they did not list it from the Tahana Member. However, Carson (1926:55), in a largely overlooked paper, lists *Dendraster perrini* (= *Merriamaster perrini*) as one of the species associated with his *Cancellaria palmeri* and stated that the specimens came from the Purisima Formation "in bluffs above beach east of hotel, Capitola, Santa Cruz Co., Calif." This material has not been available for examination, so it is uncertain whether or not *M. perrini* was correctly identified. The other elements of the listed fauna are more suggestive of an upper Pliocene age rather than the earlier age inferred for the Tahana Member of the type Purisima Formation.

Arnold (1906:27, list) recorded "*Astro-dapsis* n.sp. Merriam" from the Purisima Formation without citing a locality or stratigraphic position within the formation. Two years later he (Arnold 1908:353) listed "*Astro-dapsis*, new species, p." from the upper portion of the Purisima Formation, stating that "These upper beds are typically exposed in the sea cliffs in the vicinity of Purisima and south to the mouth of Pescadero Creek . . ." This generalized locality description would include the locality at which the present specimens were collected (as well as the locality within the San Gregorio Member of the Purisima at which the scutellid echinoids *Dendraster* and *Scutellaster* occur). Earlier, Haehl and Arnold (1904:18) listed "*Astro-dapsis* n. sp." and (ibid.:24) "*Astro-dapsis* n. sp. Merriam" (Merriam never published on this taxon) from the Purisima Formation, likewise without specific locality citation. Very probably all these citations refer to the same species. Further, inasmuch as Smith (1912:167) assigned Weaver's *Scutella perrini* to *Astro-dapsis* and Arnold

acknowledges (1906:8; 1908:345) Smith's "... assistance in determining the genera and zoologic relations of some of the new forms . . .," it seems possible that all these citations (Haehl and Arnold 1904; Arnold 1906, 1908; Smith 1912) refer to the same taxon. However, because of the lack of descriptions or illustrations, this suggestion cannot be verified unless the collections on which they are based can be found. Weathered specimens of *Merriamaster weaveri* n.sp. are suggestive of the genus *Astro-dapsis* unless the branching food grooves (Fig. 3) on the oral surface are evident, so that an assignment to this genus was not unreasonable (the genus *Merriamaster* was not established until 1911 and was not generally recognized until more than two decades later).

The specimens on which the present report is based were found and collected by the junior author of this paper while doing a geologic project under the supervision of Professor Raymond Sullivan of San Francisco State University. Morgan is responsible for the local stratigraphy presented herein, while the senior author is responsible for the identification of fossils, description of the new species, and stratigraphic correlation.

Some of the fossils from this area have been deposited in the Geology Department of the California Academy of Sciences (CAS). Most of the echinoids, some of the pectinids and a few other fossils from the present collection are deposited in the Invertebrate Collections of the Museum of Paleontology (UCMP) of the University of California (Berkeley). The Museum of Paleontology collections contain numerous other fossils from the same general area as the echinoids, but they are of less certain relative stratigraphic positions.

#### STRATIGRAPHY

The bed with the echinoids (the echinoids and some associated fossils are catalogued in the Museum of Paleontology under locality number D 3399) is exposed in the seacliff about 760 m south of the parking lot at San Gregorio Beach. It is a medium fine-grained, grey-green (un-weathered color) sandstone bed about 30 cm thick, with the sand dollars in irregularly distributed concentrations. Some of the echinoids were crushed or broken before burial, indicating some reworking before final entombment. The echinoid-bearing bed is exposed in the axial area

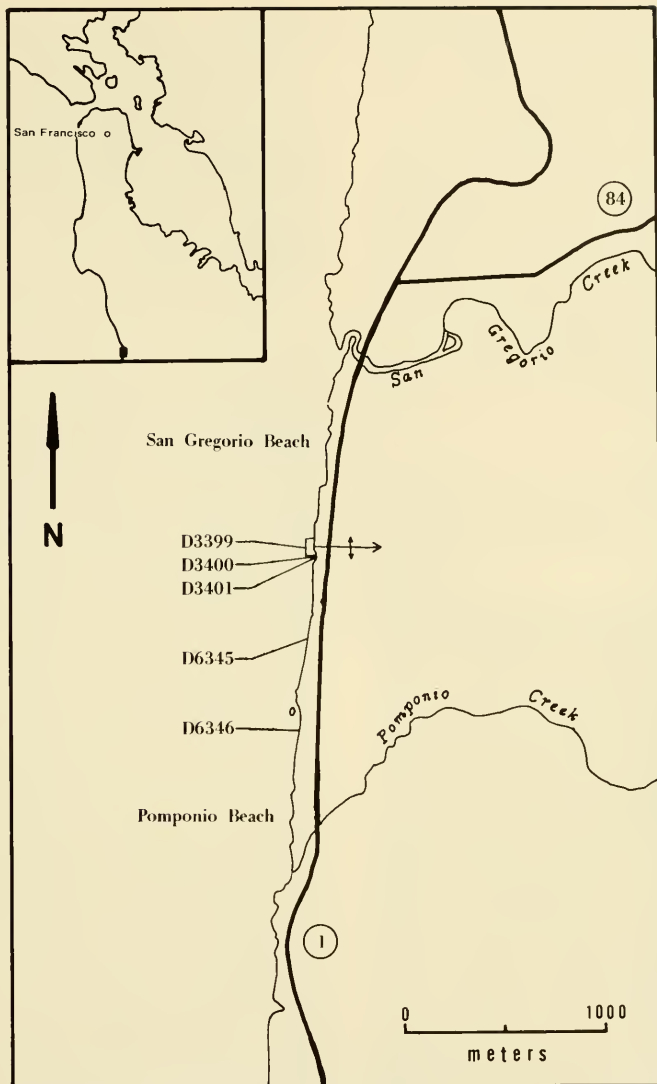


FIGURE 1. Map of San Gregorio Beach area, showing location of fossil collecting localities ("D" numbers).

of a gentle east-west trending anticline and at a maximum attains a height of about 3 m above the base of the cliff. It gradually disappears below the beach level to both the north and south. The local rock sequence (Fig. 2) is referable to the upper part of the Tahana Member of the Purisima Formation (see Cummings et al. 1962:197-200, pl. 20). The part of the Purisima Formation exposed (Fig. 1) between the axis of the anticline and San Gregorio Creek to the north is about 76 m thick and is composed of massive marine sandstones with some interbed-

ded siltstone and a rhyolitic tuff. A horizontal Quaternary non-marine terrace conglomerate up to 7 m thick unconformably overlies the older sequence. Fossil horizons generally correspond to concretionary beds or to the more calcareous strata. Two other fossiliferous beds (localities UCMP D 3400 and D 3401) occur below the echinoid-bearing stratum, with the collections being made on both sides of the anticlinal axis. Two other significant collections (UCMP locs. D 6345 and D 6346) from higher in the sequence were made from the strata exposed to the south

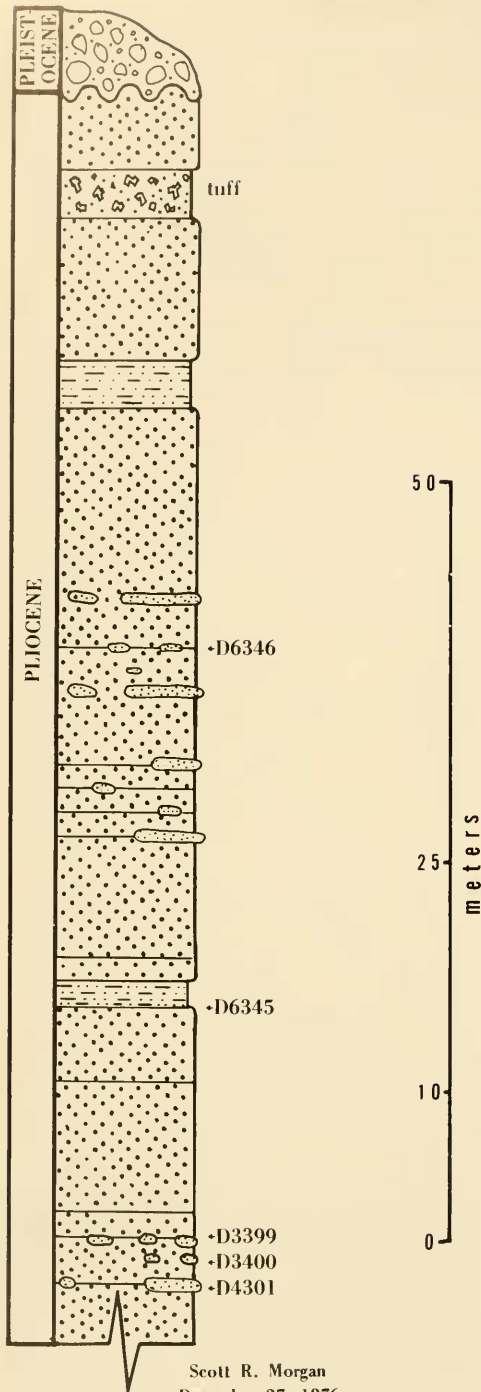


FIGURE 2. Columnar section of the Tahana Member of the Purisima Formation and overlying Quaternary terrace deposits as exposed in seaciffs between Pomponio and San Gregorio creeks, San Mateo County, California. "D" prefix numbers represent fossil collections in the Museum of Paleon-

of the axis. The same beds do not appear to be fossiliferous on the north flank of the anticline.

The sand dollars at locality D 3399 are associated with other fossils, including *Swiftopecten swifti parmeleei* (Dall), *Patinopecten (Lituyapecten) turneri* (Arnold) (hypotype UCMP 14457), *Spisula albaria* (Conrad), *Yoldia scissurata* subsp. *strigata* (Dall), *Nassarius (Caesia) grammatus* (Dall), and *Clinocardium nuttallii* (Conrad)(?).

In the bed immediately below (UCMP D 3400) the echinoid-bearing stratum, the barnacle, *Balanus (Tamiosoma) gregarius* (Conrad), is associated with *Swiftopecten swifti parmeleei*. In a bed (loc. D 3401) about 3 to 3.5 m below the echinoids, there are abundant pectens that have been identified as *Patinopecten healeyi* (Arnold) (see Arnold 1906:104, pl. 37, fig. 2 only; and Cummings et al.: photo 15, fig. 4). All pectens from this bed are like those illustrated by Arnold and by Cummings et al. and do not agree well with the most common variants of *P. healeyi* (see Hertlein and Grant 1972: pl. 21, figs. 1, 6, 7) from the San Diego Formation. About 16 m stratigraphically above the echinoid bed (UCMP 14458, loc. D 6345) a specimen of *Patinopecten (Lituyapecten) falorensis* MacNeil was found. *P. (L.) falorensis* has previously been reported from this area by MacNeil (1961:234-235). The locality description for his specimens is not precise stratigraphically but it suggests a position similar to that of the present specimen. About 41 m stratigraphically above the echinoid-bearing bed, specimens of *P. (L.) purisimaensis* (Arnold) (UCMP 14459, 14260, loc. D 6346) are present. Thus the local evidence suggests that *P. (L.) turneri*, *P. (L.) falorensis*, and *P. (L.) purisimaensis* form a sequence, occurring in that order from oldest to youngest.

Elsewhere *Patinopecten (Lituyapecten) turneri* occurs in the Merced Formation in the Estero San Antonio area (type area) near Dillon Beach, California (see Peck 1960: pl. 21, figs. 15-16). Peck (1960: table 2, pl. 21, fig. 14 [labeled as left valve but actually right valve]) also recorded *P. (L.) purisimaensis* from the Ohlson Ranch Formation near the San Andreas Fault in northwestern Sonoma County, California. Reexamination of the illustrated specimen and

←  
tology (UCMP), University of California (Berkeley), and their stratigraphic positions.



additional fragmentary specimens indicates that they should be referred to *P. (L.) falorensis*. To date, typical *P. (L.) purisimaensis* has been validly recorded from formations other than the Purisima only by Glen (1959:168, pl. 15, figs. 2, 3) from the "Merced Formation" of Pillar Point (about 22 km northwest of the *Merriamaster* locality). Elsewhere *P. (L.) falorensis* occurs in the Falor Formation (type-specimens) and the Rio Dell Formation of Humboldt County, California (MacNeil 1961:235).

#### AGE

Cummings et al. (1962:211) considered the Tahana Member of the Purisima Formation to be near the base of the Pliocene Series in the sense of the traditional usage of Pliocene in California. The formation unconformably overlies beds assigned to the Monterey Formation and which Cummings et al., (1962:197) suggested were younger than Luisian and possibly correlative with the Delmontian portion of the type Monterey Formation.

The Tahana Member is overlain by the Pomponio Member, and it in turn by the San Gregorio Member of the Purisima Formation. Fossils reported by Cummings et al. (1962:202–208) from these two members include *Patinopecten lohri* (Hertlein), *Anadara trilineata* (Conrad), and *Dendraster gibbsii* (Rémond), suggesting a correlation with the upper Jacalitos-Etchegoin succession of the Coalinga-Kettleman Hills area of the San Joaquin Valley (upper part of Faunizone E and Faunizone F of Adegoke 1969:76–80). The *Scutellaster oregonensis* of Cummings et al. (1961: photo 19, fig. 5) is not now referred to that species but is closely similar to a new species (originally identified as *S. oregonensis quaylei* in Durham and Wolfe 1958) from the uppermost beds of the type Jacalitos Formation near Coalinga. In the Jacalitos occurrence, *Scutellaster* is associated with *Dendraster gibbsii*, while *Patinopecten lohri* occurs in nearby strata. Thus the *Scutellaster* suggests that the Pomponio-San Gregorio members are correlative with the uppermost part of the type Jacalitos Formation or zonule 10 of Faunizone F of Adegoke (1969:78–79) of the Coalinga-Reef Ridge area.

The three species of *Patinopecten* (*Lityapecten*) from the Tahana Member suggest that it can be correlated with parts of the Falor Formation, the Ohlson Ranch Formation and the Merced

Formation near Dillon Beach and Bodega Bay. The stratigraphic position of the Tahana Member below the Pomponio Member suggests that it is older than the uppermost type Jacalitos Formation or Adegoke's Faunizone F of the Coalinga-Reef Ridge area, and that it is probably to be correlated with the older part of the type Jacalitos Formation or Faunizone E of Adegoke's terminology. In traditional West Coast megafaunal terminology, the age of the Tahana Member is early Pliocene, but it should be recognized that correlations based on planktonic foraminifera may show that it is of late Miocene age in terms of the European type sections.

#### SYSTEMATIC DESCRIPTIONS

##### Genus *Merriamaster* Lambert, 1911

##### *Merriamaster weaveri* n.sp.

(Figure 3)

?*Scutella perrini* Weaver in Branner, Newson and Arnold 1909:6; Weaver 1908:273(in part); non Weaver 1908:273(in part), pl. 22, fig. 2; *nec auctores*.

*Diagnosis*.—A large *Merriamaster* with less eccentric apical system, slightly longer and less flared posterior petals, and sparser and finer tuberculation than in *M. perrini*; tuberculation not as fine as in *M. arnoldi*.

*Description*.—Adult test of large size for genus, margin moderately inflated; position of apical system variable, slightly eccentric; maximum height of test anterior to apical system; petals elongate, distally with nearly parallel sides, sometimes raised adjacent to apical system; length of anterior petal about 80 percent of corresponding radius; periproct just submarginal; peristome slightly posterior; numerous moderately large tubercles within petals, tubercles in interambulacra moderately fine; internal concentric test supports 2 to 4 (rarely) as in type-species.

*Dimensions*.—Holotype (UCMP 14259) length 38.8 mm, width 37.4 mm, thickness 11.0 mm; paratype (UCMP 14443) length 47.8 mm, width +40 mm, thickness about 9–10 mm; paratype (UCMP 14445), length +51 mm, width +48.8 mm, thickness  $\pm 10.2$  mm; paratype (UCMP 14446), length  $\pm 37$  mm, width 33.5 mm, height 7.3 mm; paratype (UCMP 14449) crushed, poorly preserved, major observed diameter  $\pm 62$  mm.

*Types*.—All from UCMP loc. D 3399; holotype UCMP 14259, paratypes UCMP 14443 to 14447, 14449; paratypes CAS 58175 and 58176.

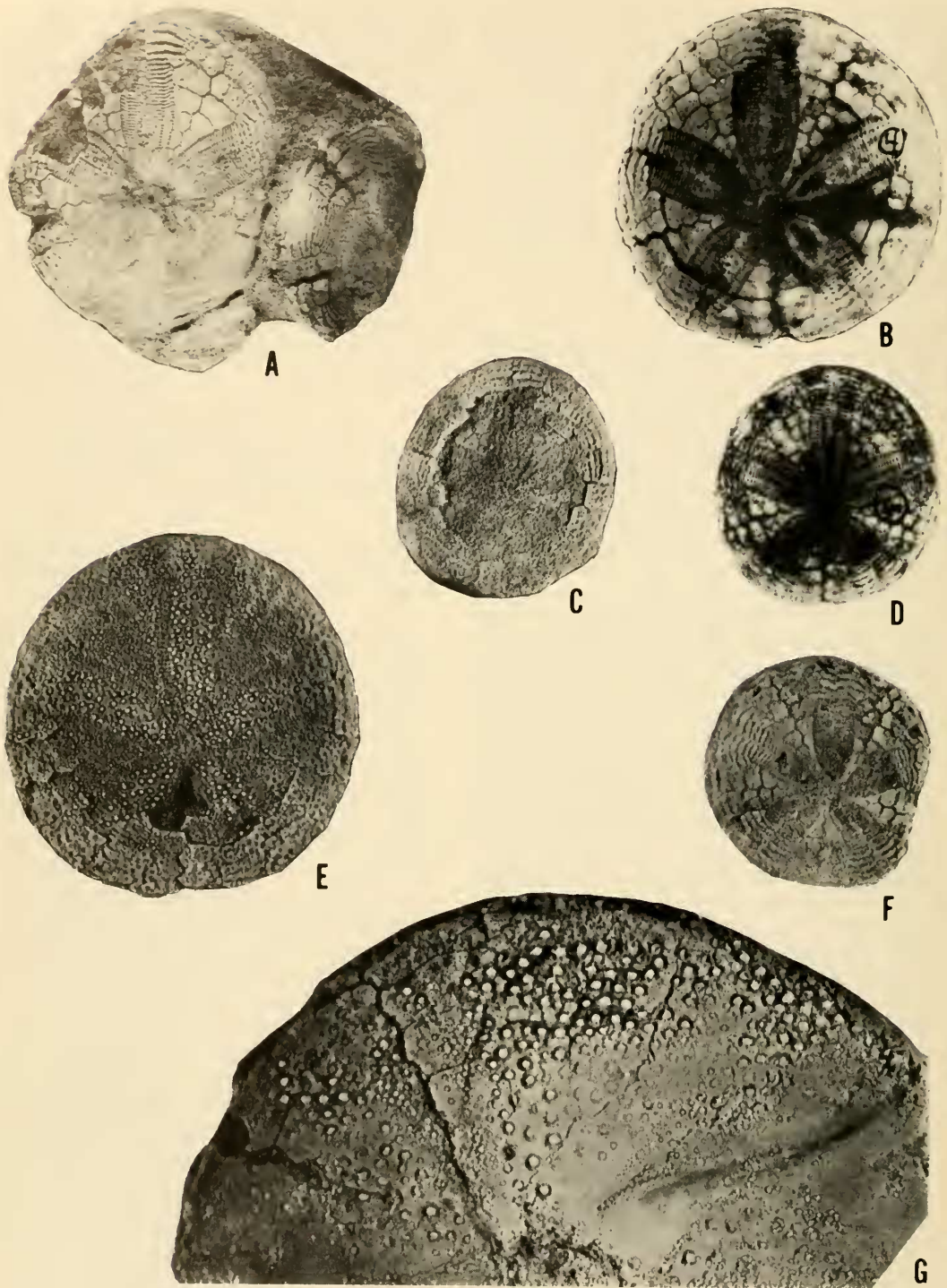


FIGURE 3. *Merriamaster weaveri* n.sp. A-D, F, approximately  $\times 1$ ; E,  $\times 1.4$ ; G,  $\times 3.4$ . (A) Paratype, UCMP 14443, part of another specimen on right side. (B) Paratype, UCMP 14445, immersed in water. (C) Paratype, CAS 58176. (D) Paratype, UCMP 14446, immersed in xylene. (E) Holotype, UCMP 14259, apical surface, note large tubercles in ambulacra. (F) Paratype, UCMP 14447. Traces of tuberculation in ambulacrum V. (G) Part of oral surface of same paratype as fig. D. Ambulacrum I in left

*Occurrence*.—UCMP loc. D 3399 (only), early Pliocene.

*Discussion*.—There are 10 reasonably well-preserved specimens, but some of them are crushed or incomplete. There are also numerous poorly preserved individuals. The species is named after C. E. Weaver who described the type-species (*Scutella perrini*) of the genus. It differs from *M. perrini* by the less eccentric apical system and the straighter, longer, and more open posterior petals. The tuberculation is coarser than that of *M. arnoldi* (Twitchell) which is nearly always associated with *M. perrini*. It differs from the species represented by the specimen from the Sargent Oil Field figured by Kew (1920:pl. 28, figs. 2a, 2c) as *Dendraster arnoldi* (now *Merriamaster arnoldi*) by the less eccentric apical system and sparser tuberculation within the aboral interambulacral areas of the new species. *Merriamaster* cf. *M. perrini* (Weaver) (Woodring and Bramlette 1950:pl. 10, figs. 11–14) from the Foxen Mudstone of the Santa Maria District differs by the sparser tubercles on the oral surface and its nearly central apical system.

*Merriamaster weaveri* differs from the associated *Dendraster sullivanii* by its less eccentric apical system, by its higher (radial dimension) interambulacral plates on the apical surface, and by its thicker margin.

*Merriamaster weaveri* is of older age than *M. perrini* and *M. arnoldi* from the late Pliocene of the San Joaquin Valley area, and presumably is older than *M. pacificus* (Kew, 1920) from the San Diego area, as well as *M. israeli* (Jordan and Hertlein, 1926) and *M. kawi* (Jordan and Hertlein, 1926) of the Pliocene of Cedros Island, Baja California, all of which have usually been assigned a "middle" Pliocene age. It may represent the ancestral stock of the genus.

#### *Dendraster sullivanii* n.sp.

(Figures 4, 5.)

*Diagnosis*.—An intermediate-sized *Dendraster* with thin margins in large adults; bivium angle about 90°; petals nearly wide open, poriferous zones wide; periproct submarginal. Large tubercles within petals.

*Description*.—Adult test of medium size, with thin margins; apical system moderately eccen-

tric, distant about 38–40% of length from posterior margin; maximum thickness just anterior to apical system; posterior petals wide, about  $\frac{2}{3}$  length of corresponding radius, only very slightly arcuate with very slight tendency to close, pore-zones tapering slightly distally; anterior petal narrow, abruptly constricted about  $\frac{1}{4}$  distance from distal end, then continuing nearly parallel sided; some demi-ambulacral plates in constricted area; anterior paired petals nearly parallel sided in distal  $\frac{2}{3}$ , then abruptly constricted to end; oral surface slightly concave, peristome just slightly posterior; tubercle pattern on oral surface not completely discernible but moderately numerous large tubercles in central  $\frac{2}{3}$  of surface; tuberculation on aboral surface mostly destroyed but some remnants present, tubercles fewer and more elevated than on *D. excentricus* and *D. gibbsii*; a few large tubercles inside poriferous area of petals as in *D. vizcainoensis*; periproct submarginal, in an admarginal position between second pair of post-basicoronal interambulacral plates.

*Dimensions*.—Holotype, length +51 mm (possibly 1–2 mm missing), width +55 mm (1–2 mm missing); height,  $\pm$  8 mm; paratype 14455, very incomplete, probably about 65 mm wide.

*Types*.—All from UCMP loc. D 3399. Holotype, UCMP 14450, paratypes UCMP 14448, 14451 to 14456; paratypes CAS 58177 to 58179.

*Occurrence*.—UCMP loc. D 3399 only, early Pliocene.

*Discussion*.—Named after Professor Raymond Sullivan. This species differs from *D. excentricus* (Agassiz) and *D. gibbsii* (Rémond) by its coarser tuberculation, larger tubercles within the petals, and thinner margin. It differs from *D. elsmerensis* Durham of similar age, which likewise has a thin margin, by its submarginal instead of marginal periproct, its smaller bivium angle, and by the presence of large tubercles within its petals (see paratypes CAS 58177 and UCMP 14453). The abrupt constriction of the anterior petal seems to be unique. The large tubercles suggest that it belongs to the group of *Dendraster vizcainoensis* Grant and Hertlein (1938:90, pl. 8, figs. 1–3).

The termination of the anterior petal, with the abrupt constriction and demi-plates, is unusual

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quadrant, note fine "tuberculation" of food groove branching about midway to ambitus. Irregular radial fracture near middle of quadrant is perradial suture (bisecting food groove). Peristome admarginal in lower left.



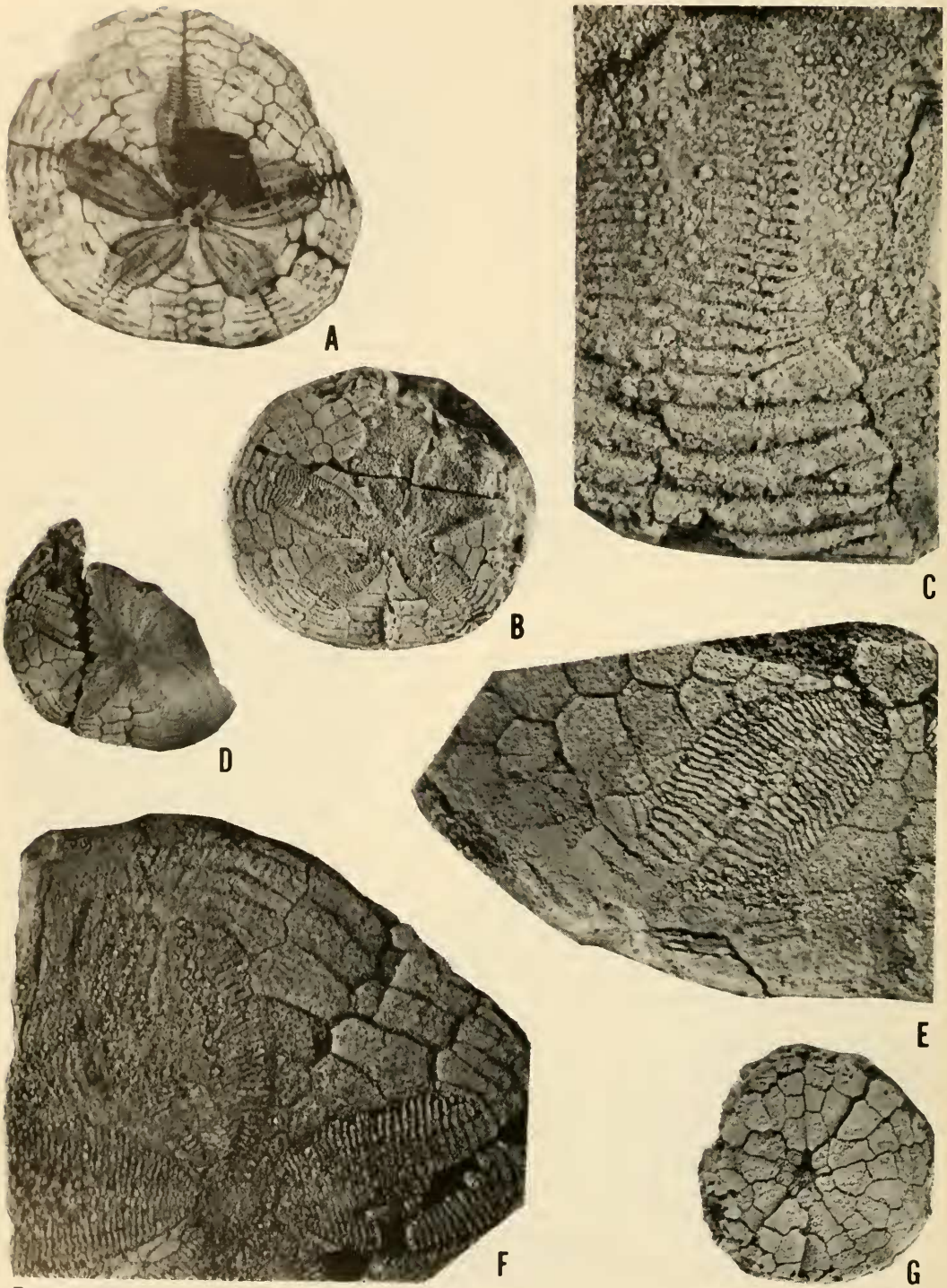
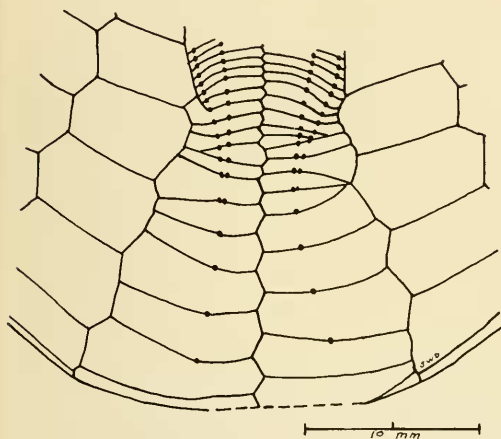


FIGURE 4. *Dendroaster sullivani* n.sp. A, B, D, G, approximately  $\times 1$ ; C,  $\times 5$ ; E, F, approximately  $\times 3.5$ . (A) Holotype, UCMP 14450, immersed in xylene. (B) Paratype, UCMP 14451. (C) Paratype, UCMP 14453, note remains of large tubercles within petal, and small tubercles outside in interambulacrum. (D) Paratype, UCMP 14452. (E) Paratype, CAS 58177, note badly eroded large tubercles in center of petal and a few small tubercles preserved in lower right. (F) Same specimen as D, note poorly eroded large tubercles in center of petal and a few small tubercles preserved in lower right.





FIGURES 5. *Dendraster sullivani* n.sp., paratype UCMP 14454. Distribution of pores and plates around tip of anterior petal. Note demi-plates around tip of petal.

for this genus, but it is clearly displayed on the holotype and paratype 14454, the only specimens on which this area is well preserved.

The exterior surface of the plates has been eroded or removed on most specimens, with external tuberculation being preserved in only a few patches. Growth lines are well shown on several specimens, a condition which is rare in species of *Dendraster*. Presumably these well-defined growth lines indicate a marked periodicity of the conditions that caused their formation. On intermediate-sized individuals (diameter about 40 mm), the margin is not as thin as on larger specimens.

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← preserved tubercles in upper central petal (Lovenian no. I). (G) Paratype, CAS 58178, weathered oral surface, interambulacrum 5, center of lower margin. Note poorly preserved large tubercles towards peristome.